

# NASA Glenn Technology Fact Sheet

## Slotted Antenna Rectangular Waveguide Plasma Source For Ion Beam And Electron Beam Production

Researchers at the NASA Glenn Research Center have developed a high density plasma generated by microwave injection using a windowless slotted antenna. Plasma probe measurements indicate that the source could be applicable for low power ion thruster applications or ion implantation applications. The plasma source which operates on the principle of electron cyclotron resonance is completely electrodeless, and therefore its operation lifetime is long, being limited only by either the microwave generator itself, or charged particle extraction grids, if used. The high density plasma source can also be used to extract an electron beam. In this regard, the device can be used as a plasma cathode neutralizer for ion source beam neutralization applications.

The purpose of the slotted antenna source is to generate, without electrode, a very uniform discharge plasma at reduced input powers and gas flow rates. The slotted antenna plasma source solves the problem of plasma generator for the ion source as well as plasma generator for the electron source. It does so in a without electrode using electron cyclotron resonance. The slotted antenna device features a series of matched radiating slot pairs that are distributed along the length of the plasma source discharge chamber. This arrangement allows the plasma production to take place in a distributed fashion, thereby giving rise to a uniform plasma profile. A uniform plasma profile is necessary for ion (electron) extraction optics uniformity. The slotted antenna design makes the approach scalable to much high powers. All that is required is the adding of additional matched radiating slots along the length of the discharge chamber. In order for the power/slot to remain constant, input microwave power must increase accordingly. Another key attribute of the slotted antenna approach described here is that an insulating window is not necessary. This allows the slotted antenna source to be used for ion beam and electron beam applications. The source is designed so that ECR takes place above each slot and the magnetic field at each slot provides a strong gradient to prevent plasmas backflow. The windowless nature of this source gives it a distinct advantage over other slotted plasma source geometries, which can only be used in non-ion beam, non-deposition type plasma applications.

### Advantages and novel features

- The slotted antenna approach makes it straightforward to scale the device up to larger areas and higher powers.
- The source can be used as either an electron or an ion source
- The high uniformity makes it applicable for plasma processing applications
- Operation at low pressure  $<1\text{e-}4$  Torr is ideal for plasma processing
- No electromagnets are required
- High exit plane ion current densities will yield desired high etch or deposition rates
- No microwave window is required.

### Patent

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